INTERNATIONAL STANDARD

ISO 16505

Second edition
2019-07

Road vehicles — Ergonomic and performance aspects of Camera Monitor Systems — Requirements and test procedures

Véhicules routiers — Aspects ergonomiques et de performance des caméras embarquées — Exigences et procédures d'essai

Reference number
ISO 16505:2019(E)

© ISO 2019



COPYRIGHT PROTECTED DOCUMENT

© ISO 2019

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

© ISO 2019 – All rights reserved

Contents

Page

Foreword ..... **v**

Introduction ..... **vi**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**
3.1 Vehicle related terms and definitions 1
3.2 Mirror related terms and definitions 2
3.3 Camera related terms and definitions 12
3.4 Monitor related terms and definitions 15
3.5 Camera Monitor System based terms and definitions 23

4 Symbols and abbreviated terms **33**

5 General information and use case definitions **36**

6 Requirements **40**
6.1 System documentation 40
6.2 Intended use 41
6.2.1 Default view 41
6.2.2 Adjusted default view 41
6.2.3 Temporary modified view 41
6.2.4 Luminance and contrast adjustment 42
6.2.5 Overlays 42
6.3 Operating readiness (system availability) 42
6.4 Field of view 43
6.5 Magnification and resolution 43
6.5.1 Average magnification factor 43
6.5.2 Minimum magnification factor 43
6.5.3 Resolution (MTF) 44
6.6 Magnification aspect ratio 45
6.7 Monitor integration inside the vehicle 45
6.8 Image quality 46
6.8.1 Monitor isotropy 46
6.8.2 Luminance and contrast rendering 47
6.8.3 Colour rendering 47
6.8.4 Artefacts 48
6.8.5 Sharpness and depth of field 49
6.8.6 Geometric distortion 49
6.8.7 Further image quality requirements 50
6.9 Time behaviour 50
6.9.1 Frame rate 50
6.9.2 Image formation time 50
6.9.3 System latency 50
6.10 Failure behaviour 50
6.11 Quality and further ergonomic requirements 50
6.11.1 Needs of older persons 51
6.12 Influences from weather and environment 51

7 Test methods **51**
7.1 System documentation 51
7.2 Intended use 51
7.2.1 Default view 51
7.2.2 Adjusted default view 51
7.2.3 Temporary modified view 52
7.2.4 Luminance and contrast adjustment 52
7.2.5 Overlays 52

© ISO 2019 – All rights reserved

7.3 Operating readiness (system availability) 52
7.4 Field of view 54
7.5 Magnification and resolution 54
7.5.1 Average magnification factor 54
7.5.2 Minimum magnification factor 55
7.5.3 Resolution (MTF) 57
7.6 Magnification aspect ratio 60
7.7 Monitor integration inside the vehicle 60
7.8 Image quality 61
7.8.1 Monitor isotropy 61
7.8.2 Luminance and contrast rendering 63
7.8.3 Colour rendering 71
7.8.4 Artefacts 74
7.8.5 Sharpness, resolution, and depth of field 75
7.8.6 Geometric distortion 77
7.8.7 Further Image quality requirements 77
7.9 Time behaviour 77
7.9.1 Frame rate 77
7.9.2 Image formation time 77
7.9.3 System latency 77
7.10 Failure behaviour 78
7.11 Quality and further ergonomic requirements 79
7.11.1 Needs of older persons 79
7.12 Influences from weather and environment 79

8 Functional safety 79

Annex A (normative) **Standard application on UN Regulation No. 46 class II and IV mirrors in commercial vehicles 80**

Annex B (informative) **Formula applications, explanations, and guidelines 85**

Annex C (informative) **Calculation of the dimensional magnification and of a correction factor to obtain the angular magnification 120**

Annex D (informative) **Complementary information for resolution measurement 125**

Annex E (informative) **Correlation between Resolution (MTF) and spatial frequency measured using SFR method for depth of field evaluation or sharpness evaluation 134**

Annex F (informative) **Complementary charts and method for long distance measurements 139**

Annex G (informative) **Distortion measurement 142**

Bibliography 149

 © ISO 2019 – All rights reserved

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 35, *Lighting and visibility*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This second edition cancels and replaces the first edition (ISO 16505:2015), of which it constitutes a minor revision.

The main changes compared to the previous edition are as follows:

— 6.1 has been added, and all subsequent subclauses in Clause 6 have been renumbered, in order to align with the subclause structure in Clause 7.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

© ISO 2019 – All rights reserved

Introduction

The purpose of this document is to give minimum safety, ergonomic, and performance requirements and test methods for Camera Monitor Systems (CMS) to replace mandatory inside and outside rearview mirrors for road vehicles (e.g. classes I to IV as defined in UN Regulation No. 46). This document can follow updates of referred national regulations that influence the included contents.

Where possible, the requirements established for a CMS providing a specific legally prescribed field of view are based on the properties of conventional state of the art mirror systems providing that field of view.

The CMS is treated as a functional system in regard to requirement definitions and performance tests.

This document outlines general requirements and test methods regarding the basic aspects of CMS; e.g. intended use, operating readiness, field of view, magnification, etc.

Furthermore, this document outlines requirements and test methods regarding the necessary object size and resolution provided by the CMS. Besides the properties of the mirror system to be replaced, those requirements are also based on physical aspects of the human operator (e.g. visual acuity).

The given requirements follow the assumption, that the CMS provides an ideal mapping of the real-world scene. To correspond to reality, this document also provides requirements and test methods for all relevant parameters that worsen the ideal mapping (e.g. isotropy or artefacts).

Finally, this document gives requirements and test methods regarding the aspects of time behaviour and failure behaviour.

All requirements are established to be as generic as possible, i.e. that these are possible to apply to any of the covered rearview mirrors. If additional or specific information is required for certain mirrors, these are provided in separate annexes.

This document declares that CMS replacing legally prescribed mirrors have to be considered as safety-relevant systems and therefore, relevant safety standards (e.g. ISO 26262) have to be considered.

© ISO 2019 – All rights reserved

Road vehicles — Ergonomic and performance aspects of Camera Monitor Systems — Requirements and test procedures

1 Scope

This document gives minimum safety, ergonomic, and performance requirements for Camera Monitor Systems to replace mandatory inside and outside rearview mirrors for road vehicles (e.g. classes I to IV as defined in UN Regulation No. 46). It addresses Camera Monitor Systems (CMS) that will be used in road vehicles to present the required outside information of a specific field of view inside the vehicle. These specifications are intended to be independent of different camera and display technologies unless otherwise stated explicitly. Advanced driver assistance systems (ADAS), such as parking aids, are not part of this document.

NOTE 1 Mirror classes V and VI (as defined in UN Regulation No. 46) are not in scope of this document since the requirements are already defined in UN Regulation No. 46.

NOTE 2 The definitions and requirements in this document are formulated with regard to a system structure, where one camera captures one legally prescribed field of view and one monitor displays one legally prescribed field of view. Of course, also other system structures (e.g. with one monitor displaying two legally prescribed fields of view) are within the scope of this document. For those systems, either the system supplier or the vehicle manufacturer has to prove that the resulting system fulfils the requirements given in Clause 6.

NOTE 3 Whenever the phrases “field of view” or “field of vision” are used, then both have the same meaning and are to be used in parallel.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 Vehicle related terms and definitions

3.1.1
vehicle
vehicle with a combustion engine and/or electric driving motor, intended for use on the road, with or without external body components added, having a permissible maximum mass of at least 400 kg and a maximum design speed equal to or exceeding 50 km/h

Note 1 to entry: Vehicles of categories M1, M2, M3, N1, N2 and N3 (see UN Regulation No. 46).

[SOURCE: ISO 13043:2011, 3.1]

© ISO 2019 – All rights reserved

3.1.2
vehicle coordinate system
positive x-axis pointing into the opposite of the forward movement direction of the vehicle, the z-axis being orthogonal to the ground plane pointing upwards and the y-axis pointing to the right seen in forward movement direction thus forming a right-handed coordinate system

3.1.3
driver's ocular points
points that are uniquely defined for each vehicle

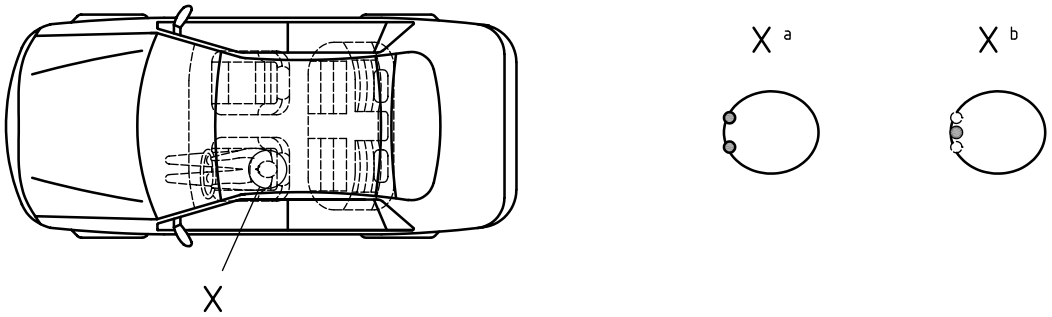
Note 1 to entry: See Figure 1.

Note 2 to entry: These points are related to data given by the vehicle manufacturer following definitions of the responsible national body.

EXAMPLE "The driver's ocular points" means two points 65 mm apart and 635 mm vertically above point *R* of the driver's seat as defined in Annex B. The straight line joining these points runs perpendicular to the vertical longitudinal median plane of the vehicle. The centre of the segment joining the two ocular points is in a vertical longitudinal plane which has to pass through the centre of the driver's designated seating position, as specified by the vehicle manufacturer.

3.1.4
driver ocular reference point
ORP
middle point between the two ocular points of the driver

Note 1 to entry: See Figure 1.



a Ocular points.

b Ocular reference point.

Figure 1 — Driver ocular reference point

EXAMPLE The two ocular points of the driver uses 635 mm vertically above point *R* as shown in the example given in *driver's ocular points* (3.1.3).

3.2 Mirror related terms and definitions

3.2.1
mirror
device with a reflective surface mounted to the bodywork of a vehicle

Note 1 to entry: It is used to see the required outside information of a specific field of view by indirect vision.

Note 2 to entry: The definitions from *mirror distance to driver ocular reference point* (3.2.2) to *mirror angular resolution* (3.2.28) assume an ideal mirror and do not deal with artefacts like low quality surface, dirt, etc.

© ISO 2019 – All rights reserved

3.2.2
mirror distance to driver ocular reference point
distance from the driver ocular reference point to the centre of the mirror

Note 1 to entry: See Figure 2.

Note 2 to entry: It is denoted as a_{mirror} and is measured in metres.

Note 3 to entry: The mirror distance to driver ocular reference point influences the resolution and the magnification requirements for a CMS replacing a mirror. The designed resolution and magnification of a CMS should take into account that this distance is usually lower than the maximum values given in the following subclauses.

3.2.3
maximum mirror distance to driver ocular reference point
<driver side>maximum value for a_{mirror} as found in existing homologated vehicles for the given mirror class on the driver side

Note 1 to entry: It is denoted as $a_{mirror/driver/max}$ and is measured in metres:

— for UN Regulation No. 46 class I mirrors, this value is defined as $a_{mirror/driver/max}$ = 1,05 m;

— for UN Regulation No. 46 class II mirrors, this value is defined as $a_{mirror/driver/max}$ = 1,7 m;

— for UN Regulation No. 46 class III mirrors, this value is defined as $a_{mirror/driver/max}$ = 1,2 m;

— for UN Regulation No. 46 class IV mirrors, this value is defined as $a_{mirror/driver/max}$ = 1,7 m.

Note 2 to entry: The above values represent the maximum distances for mass produced vehicles of MY 2013 (based upon 2013 survey).

Note 3 to entry: See B.6.2 for more information on the values for class II and class IV mirrors.

3.2.4
maximum mirror distance to driver ocular reference point
<passenger side>maximum value for a_{mirror} as found in existing homologated vehicles for the given mirror class on the passenger side

Note 1 to entry: It is denoted as $a_{mirror/passenger/max}$ and is measured in metres:

— for UN Regulation No. 46 class II mirrors, this value is defined as $a_{mirror/passenger/max}$ = 2,6 m;

— for UN Regulation No. 46 class III mirrors, this value is defined as $a_{mirror/passenger/max}$ = 1,9 m;

— for UN Regulation No. 46 class IV mirrors, this value is defined as $a_{mirror/passenger/max}$ = 2,6 m;

— for main mirrors on cab-over-engine type trucks according to Article 44 of Japanese Safety Regulations for Road Vehicles, this value is defined as $a_{mirror/passenger/max}$ = 2,5 m;

— for main mirrors on motor vehicles with a passenger capacity of 11 persons or more according to Article 44 of Japanese Safety Regulations for Road Vehicles, this value is defined as $a_{mirror/passenger/max}$ = 2,5 m.

— for mirrors on the other vehicle category in Japan refer to Article 44 of Japanese Safety Regulations for Road Vehicles.

Note 2 to entry: The above values represent the maximum distances for mass produced vehicles of MY 2013(based upon 2013 survey).

Note 3 to entry: See B.6.3 for more information on the values for class II and class IV mirrors.

Note 4 to entry: According to Article 44 of Japanese Safety Regulations for Road Vehicles main mirror means “Those mirrors used mainly for observing obstacles showing up around the rear portion on the left side of the vehicle”. See Figures B.5, B.6, and B.7.

© ISO 2019 – All rights reserved

3.2.5
mirror viewing angle
total angle between the ray leaving the eye-point and reaching an object after being reflected from the mirror surface, i.e. two times the angle between the driver's line of sight and the surface normal of the mirror

Note 1 to entry: See Figure 3.

Note 2 to entry: It is denoted as β_{mirror} and is measured in degrees.

3.2.6
minimum mirror viewing angle
<driver side>minimum value for β_{mirror} as found in existing homologated vehicles for the given mirror class on the driver side

Note 1 to entry: It is denoted as $\beta_{mirror/driver/min}$ and is measured in degrees:

— for UN Regulation No. 46 class I mirrors, this value is defined as $\beta_{mirror/driver/min} = 20$ °;

— for UN Regulation No. 46 class II mirrors, this value is defined as $\beta_{mirror/driver/min} = 55$ °;

— for UN Regulation No. 46 class III mirrors, this value is defined as $\beta_{mirror/driver/min} = 30$ °;

— for UN Regulation No. 46 class IV mirrors, this value is defined as $\beta_{mirror/driver/min} = 55$ °.

Note 2 to entry: The above values represent the minimum angles for mass produced vehicles of MY 2013 (based upon 2013 survey) regarding the required field of view.

3.2.7
maximum mirror viewing angle
<driver side>maximum value for β_{mirror} as found in existing homologated vehicles for the given mirror class on the driver side

Note 1 to entry: It is denoted as $\beta_{mirror/driver/max}$ and is measured in degrees:

— for UN Regulation No. 46 class I mirrors, this value is defined as $\beta_{mirror/driver/max} = 65$ °;

— for UN Regulation No. 46 class II mirrors, this value is defined as $\beta_{mirror/driver/max} = 75$ °;

— for UN Regulation No. 46 class III mirrors, this value is defined as $\beta_{mirror/driver/max} = 65$ °;

— for UN Regulation No. 46 class IV mirrors, this value is defined as $\beta_{mirror/driver/max} = 125$ °.

Note 2 to entry: The above values represent the maximum angles for mass produced vehicles of MY 2013 (based upon 2013 survey) regarding the required field of view.

3.2.8
minimum mirror viewing angle
<passenger side>minimum value for β_{mirror} as found in existing homologated vehicles for the given mirror class on the passenger side

Note 1 to entry: It is denoted as $\beta_{mirror/passenger/min}$ and is measured in degrees:

— for UN Regulation No. 46 class II mirrors, this value is defined as $\beta_{mirror/passenger/min} = 80$ °;

— for UN Regulation No. 46 class III mirrors, this value is defined as $\beta_{mirror/passenger/min} = 55$ °;

— for UN Regulation No. 46 class IV, this value is defined as $\beta_{mirror/passenger/min} = 80$ °;

— for main mirrors on cab-over-engine type trucks according to Article 44 of Japanese Safety Regulations for Road Vehicles, this value is defined as $\beta_{mirror/passenger/min} = 54$ °;

— for main mirrors on motor vehicles with a passenger capacity of 11 persons or more according to Article 44 of Japanese Safety Regulations for Road Vehicles, this value is defined as $\beta_{mirror/passenger/min} = 50{,}5$ °.

© ISO 2019 – All rights reserved

— for mirrors on the other vehicle category in Japan refer to Article 44 of Japanese Safety Regulations for Road Vehicles.

Note 2 to entry: The above values represent the minimum angles for mass produced vehicles of MY 2013 (based upon 2013 survey) regarding the required field of view.

Note 3 to entry: According to Article 44 of Japanese Safety Regulations for Road Vehicles, main mirror means "Those mirrors used mainly for observing obstacles showing up around the rear portion on the left side of the vehicle". See Figures B.5, B.6, and B.7.

3.2.9
maximum mirror viewing angle
<passenger side>maximum value for β_{mirror} as found in existing homologated vehicles for the given mirror class on the passenger side

Note 1 to entry: It is denoted as $\beta_{mirror/passenger/max}$ and is measured in degrees:

— for UN Regulation No. 46 class II mirrors, this value is defined as $\beta_{mirror/passenger/max}$ = 95 °;

— for UN Regulation No. 46 class III mirrors, this value is defined as $\beta_{mirror/passenger/max}$ = 85 °;

— for UN Regulation No. 46 class IV mirrors, this value is defined as $\beta_{mirror/passenger/max}$ = 150 °;

— for main mirrors on cab-over-engine type trucks according to Article 44 of Japanese Safety Regulations for Road Vehicles, this value is defined as $\beta_{mirror/passenger/max}$ = 111 °;

— for main mirrors on motor vehicles with a passenger capacity of 11 persons or more according to Article 44 of Japanese Safety Regulations for Road Vehicles, this value is defined as $\beta_{mirror/passenger/max}$ = 64 °.

— for mirrors on the other vehicle category in Japan refer to Article 44 of Japanese Safety Regulations for Road Vehicles.

Note 2 to entry: The above values represent the maximum angles for mass produced vehicles of MY 2013 (based upon 2013 survey) regarding the required field of view.

Note 3 to entry: According to Article 44 of Japanese Safety Regulations for Road Vehicles main mirror means "Those mirrors used mainly for observing obstacles showing up around the rear portion on the left side of the vehicle". See Figures B.5, B.6, and B.7.

3.2.10
distance from mirror to object
distance from the mirror to an object being viewed by the driver

Note 1 to entry: See Figure B.14.

Note 2 to entry: It is denoted as d_{object} and is measured in meters.

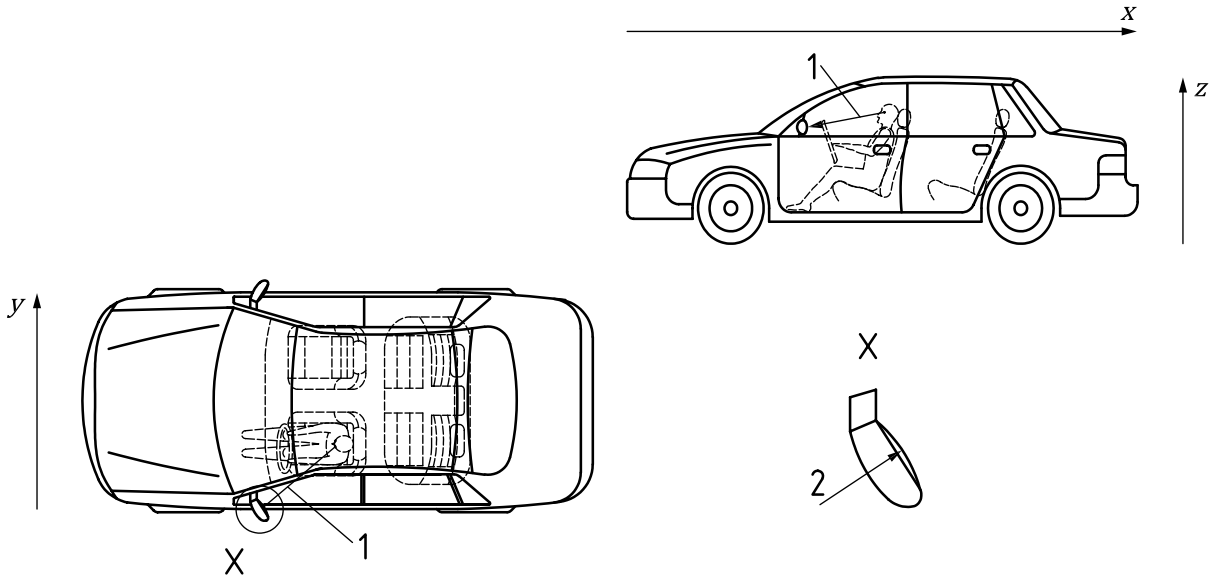
3.2.11
mirror radius of curvature
radius of the sphere that specifies the shape of a spherical mirror surface

Note 1 to entry: See Figure 2.

Note 2 to entry: For convex spherical mirrors with the reflective layer on the convex surface, this value is positive.

Note 3 to entry: It is denoted as r_{mirror} and is measured in metres.

© ISO 2019 – All rights reserved



Key

1 a_{mirror}

2 r_{mirror}

Figure 2 — Mirror radius of curvature

3.2.12
mirror minimum allowed radius of curvature
minimum allowed value for r_{mirror} as defined by the responsible national body

Note 1 to entry: It is denoted as $r_{mirror/min}$ and is measured in metres.

Note 2 to entry: The values given below are examples:

— for UN Regulation No. 46 class I spherical convex mirrors, this value is defined as $r_{mirror/min}$ = 1,2 m;

— for UN Regulation No. 46 class II spherical convex mirrors, this value is defined as $r_{mirror/min}$ = 1,2 m;

— for UN Regulation No. 46 class III spherical convex mirrors, this value is defined as $r_{mirror/min}$ = 1,2 m;

— for UN Regulation No. 46 class IV spherical convex mirrors, this value is defined as $r_{mirror/min}$ = 0,3 m;

— for main mirrors on cab-over-engine type trucks according to Article 44 of Japanese Safety Regulations for Road Vehicles, this value is defined as $r_{mirror/min}$ = 0,6 m;

— for main mirrors on motor vehicles with a passenger capacity of 11 persons or more according to Article 44 of Japanese Safety Regulations for Road Vehicles, this value is defined as $r_{mirror/min}$ = 0,6 m;

— for mirrors on the other vehicle category in Japan refer to Article 44 of Japanese Safety Regulations for Road Vehicles;

— FMVSS 111 only allows for plane mirrors where $r_{mirror/min}$ is infinite on the driver side; however, on the passenger side of the vehicle, FMVSS 111 defines a spherical convex mirror with a minimum radius of $r_{mirror/min}$ = 0,889 m.

Note 3 to entry: According to Article 44 of Japanese Safety Regulations for Road Vehicles, main mirror means "Those mirrors used mainly for observing obstacles showing up around the rear portion on the left side of the vehicle". See Figures B.5, B.6, and B.7.

© ISO 2019 – All rights reserved

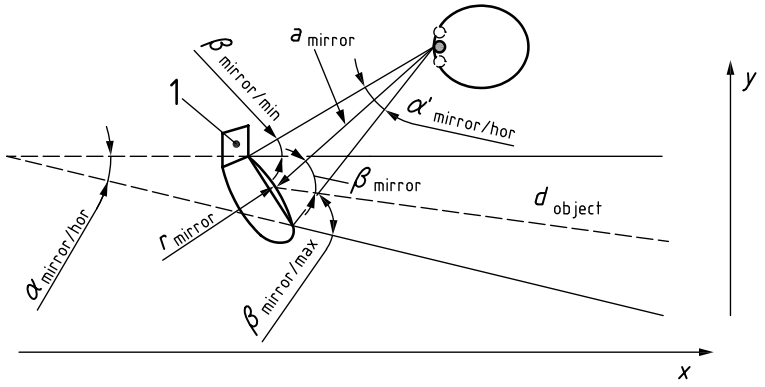
3.2.13
mirror angular size
angle under which the driver perceives the mirror

Note 1 to entry: See *mirror horizontal angular size* (3.2.14) and *mirror vertical angular size* (3.2.15) for details and differentiation between horizontal and vertical direction.

3.2.14
mirror horizontal angular size
angle between the lines from the ORP to the left and right edge (in y-direction) of the reflective mirror surface

Note 1 to entry: See Figure 3.

Note 2 to entry: It is denoted as $\alpha'_{mirror/hor}$ and is measured in degrees.



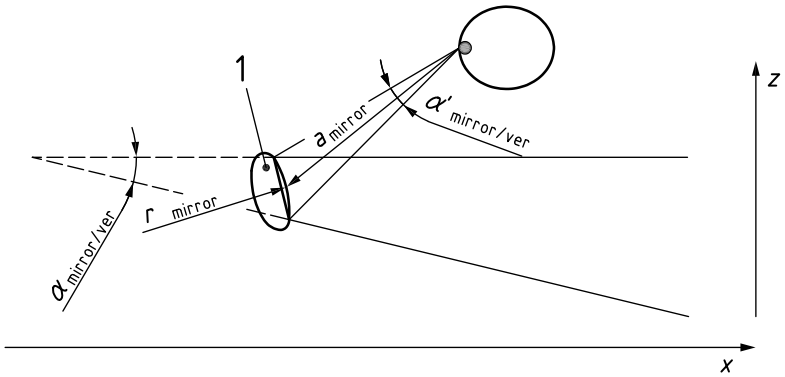
Key
1 mirror

Figure 3 — Mirror horizontal angular size (bird's eye view)

3.2.15
mirror vertical angular size
angle between the lines from the ORP to the top and bottom edge in (z-direction) of the reflective mirror surface

Note 1 to entry: See Figure 4.

Note 2 to entry: It is denoted as $\alpha'_{mirror/ver}$ and is measured in degrees.



Key
1 mirror

Figure 4 — Mirror vertical angular size (side view)

© ISO 2019 – All rights reserved

3.2.16
field of view
space defined by all rays of light (lines from object points to the reflective mirror surface) that are still reflected into the driver's imaginary monocular eye point at the ORP

Note 1 to entry: This space can be approximated by a pyramid with its base lying in the y-z-plane.

3.2.17
horizontal field of view
angle between the leftmost and the rightmost ray of the field of view projected to the x-y-plane

Note 1 to entry: It is denoted as $\alpha_{mirror/hor}$ and is measured in degrees.

3.2.18
minimum horizontal field of view
minimum allowed value for $\alpha_{mirror/hor}$ as defined by the responsible national body

Note 1 to entry: It is denoted as $\alpha_{mirror/hor/min}$ and is measured in degrees.

Note 2 to entry: Information on $\alpha_{mirror/hor/min}$ for different mirror classes is given in B.2.1.

3.2.19
vertical field of view
angle between the topmost and the bottommost ray of the field of view projected to the x-z-plane

Note 1 to entry: It is denoted as $\alpha_{mirror/ver}$ and is measured in degrees.

3.2.20
minimum vertical field of view
minimum allowed value for $\alpha_{mirror/ver}$ as defined by the responsible national body

Note 1 to entry: It is denoted as $\alpha_{mirror/ver/min}$ and is measured in degrees.

Note 2 to entry: Information on $\alpha_{mirror/ver/min}$ for different mirror classes is given in B.2.2.

3.2.21
mirror magnification factor
relationship between the correct size of an object and its perceived size when seen through the mirror

Note 1 to entry: It is dependent on the distance from the ORP to the mirror a_{mirror} (see 3.2.2), the radius of the mirror r_{mirror} (see 3.2.11), the distance to the object d_{object} (see 3.2.10), and the mirror viewing angle β_{mirror} (see 3.2.5). It is denoted as $M_{mirror.}$

Note 2 to entry: For convex spherical rearview mirrors, the magnification factor is below 1, i.e. objects in a rearview mirror appear smaller than they really are. For plane mirrors with unit magnification, the magnification factor is equal to 1, i.e. there is no magnification.

Note 3 to entry: For a formula describing the magnification factor variation over the mirror, refer to B.3.

3.2.22
mirror average magnification factor
average value for the magnification based on a mirror with minimum radius $r_{mirror/min}$ and maximum distance to the ORP $a_{mirror/max}$

Note 1 to entry: It is denoted as $M_{mirror/avg}$.

Note 2 to entry: It is derived as the average over the relevant range of viewing angles β_{mirror} at the horizontal centre line of the mirror and distances d_{object}.

Note 3 to entry: See *mirror average magnification factor (driver side)* (3.2.23) and *mirror average magnification factor (passenger side)* (3.2.24) for details and differentiation between driver and passenger side.

© ISO 2019 – All rights reserved

3.2.23
mirror average magnification factor
<driver side>average magnification factor for M_{mirror} as found in existing homologated vehicles for the given mirror class on the driver side

Note 1 to entry: It is denoted as $M_{mirror/driver/avg}$:

— for UN Regulation No. 46 class I mirrors, this value is defined as $M_{mirror/driver/avg}$ = 0,33;

— for UN Regulation No. 46 class II mirrors, this value is defined as $M_{mirror/driver/avg}$ = 0,23;

— for UN Regulation No. 46 class III mirrors, this value is defined as $M_{mirror/driver/avg}$ = 0,31;

— for UN Regulation No. 46 class IV mirrors, this value is defined as $M_{mirror/driver/avg}$ = 0,065;

— for an FMVSS 111 plane driver mirror, this value is $M_{mirror/driver/avg}$ = 1.

Note 2 to entry: The above values were derived from mass produced vehicles of MY 2013 (based upon 2013 survey).

Note 3 to entry: For detailed information how these values were derived, refer to B.3.

Note 4 to entry: For additional recommendations concerning commercial vehicles, refer to A.3.3.

3.2.24
mirror average magnification factor
<passenger side>average magnification factor for M_{mirror} as found in existing homologated vehicles for the given class on the passenger side

Note 1 to entry: It is denoted as $M_{mirror/passenger/avg}$:

— for UN Regulation No. 46 class II mirrors, this value is defined as $M_{mirror/passenger/avg}$ = 0,15;

— for UN Regulation No. 46 class III mirrors, this value is defined as $M_{mirror/passenger/avg}$ = 0,20;

— for UN Regulation No. 46 class IV mirrors, this value is defined as $M_{mirror/passenger/avg}$ = 0,036;

— for an FMVSS 111 passenger mirror, this value is defined as $M_{mirror/passenger/avg}$ = 0,17;

— for main mirrors on cab-over-engine type trucks according to Article 44 of Japanese Safety Regulations for Road Vehicles, this value is $M_{mirror/passenger/avg}$ = 0,088;

— for main mirrors on motor vehicles with a passenger capacity of 11 persons or more according to Article 44 of Japanese Safety Regulations for Road Vehicles, this value is $M_{mirror/passenger/avg}$ = 0,10;

— for mirrors on the other vehicle category in Japan refer to Article 44 of Japanese Safety Regulations for Road Vehicles.

Note 2 to entry: The above values were derived from mass produced vehicles of MY 2013 (based upon 2013 survey).

Note 3 to entry: For detailed information how these values were derived, refer to B.3.

Note 4 to entry: For additional recommendations concerning commercial vehicles, refer to A.3.3.

Note 5 to entry: According to Article 44 of Japanese Safety Regulations for Road Vehicles, main mirror means "Those mirrors used mainly for observing obstacles showing up around the rear portion on the left side of the vehicle". See Figures B.5, B.6, and B.7.

3.2.25
mirror minimum magnification factor
minimum value for the magnification based on a mirror with minimum radius $r_{mirror/min}$ and maximum distance to the ORP $a_{mirror/max}$; it is derived from the maximum viewing angle $\beta_{mirror/max}$ at the horizontal centre line of the mirror within the relevant range and the distance $d_{object} = \infty$

Note 1 to entry: It is denoted as $M_{mirror/min}$.

© ISO 2019 – All rights reserved

Note 2 to entry: See *mirror minimum magnification factor (driver side)* (3.2.26) and *mirror minimum magnification factor (passenger side)* (3.2.27) for details and differentiation between driver and passenger side.

3.2.26
mirror minimum magnification factor
<driver side>minimum magnification factor for M_{mirror} as found in existing homologated vehicles for the given class on the driver side

Note 1 to entry: It is denoted as $M_{mirror/driver/min}$:

— for UN Regulation No. 46 class I mirrors, this value is defined as $M_{mirror/driver/min} = 0{,}31$;

— for UN Regulation No. 46 class II mirrors, this value is defined as $M_{mirror/driver/min} = 0{,}21$;

— for UN Regulation No. 46 class III mirrors, this value is defined as $M_{mirror/driver/min} = 0{,}29$;

— for UN Regulation No. 46 class IV mirrors, this value is defined as $M_{mirror/driver/min} = 0{,}037$;

— for an FMVSS 111 plane driver mirror, this value is $M_{mirror/driver/min} = 1$.

Note 2 to entry: The above values were derived from mass produced vehicles of MY 2013 (based upon 2013 survey).

Note 3 to entry: For detailed information how these values were derived, refer to B.3.

Note 4 to entry: For additional recommendations concerning commercial vehicles, refer to A.3.3.2.

3.2.27
mirror minimum magnification factor
<passenger side>minimum magnification factor for M_{mirror} as found in existing homologated vehicles for the given class on the passenger side

Note 1 to entry: It is denoted as $M_{mirror/passenger/min}$:

— for UN Regulation No. 46 class II mirrors, this value is defined as $M_{mirror/passenger/min} = 0{,}13$,

— for UN Regulation No. 46 class III mirrors, this value is defined as $M_{mirror/passenger/min} = 0{,}19$;

— for UN Regulation No. 46 class IV mirrors, this value is defined as $M_{mirror/passenger/min} = 0{,}014$;

— for an FMVSS 111 passenger mirror, this value is defined as $M_{mirror/passenger/min} = 0{,}17$;

— for main mirrors on cab-over-engine type trucks according to Article 44 of Japanese Safety Regulations for Road Vehicles, this value is $M_{mirror/passenger/min} = 0{,}061$;

— for main mirrors on motor vehicles with a passenger capacity of 11 persons or more according to Article 44 of Japanese Safety Regulations for Road Vehicles, this value is $M_{mirror/passenger/min} = 0{,}094$.

Note 2 to entry: The above values were derived from mass produced vehicles of MY 2013 (based upon 2013 survey).

Note 3 to entry: For detailed information how these values were derived, refer to B.3.

Note 4 to entry: For additional recommendations concerning commercial vehicles, refer to A.3.3.2.

Note 5 to entry: According to Article 44 of Japanese Safety Regulations for Road Vehicles, main mirror means “Those mirrors used mainly for observing obstacles showing up around the rear portion on the left side of the vehicle”. See Figures B.5, B.6, and B.7.

© ISO 2019 – All rights reserved

3.2.28
mirror angular resolution
parameter that describes the ability of a mirror to resolve small details in a reflected scene

Note 1 to entry: In principle, a mirror can resolve an unlimited amount of detail. Nevertheless, in combination with the human eye, the angular resolution of a driver seeing through the rear view mirror of a vehicle is limited by the angular resolution of the human eye. The smaller the angular resolution of the human eye, the smaller the details can be that are still resolved by the driver, i.e. in contrast to the pixel resolution of cameras smaller values for the angular resolution indicate a higher quality vision.

3.2.29
visual acuity of the human eye
ability of the human eye and human visual system to resolve small details; it is different for each person and usually degrades with increasing age of the person

Note 1 to entry: It is measured using a Landolt C test (see ISO 8596:2009) at an optician, denoted as V_{eye} and measured in [1/arcmin].

Note 2 to entry: Usually, national bodies define a minimum visual acuity for acquiring a driver's license. A visual acuity of 1 is reached if a test person has correctly identified the direction of 60 % of the Landolt C openings, assuming that the Landolt C openings are of a size such that the openings are visible (from the test person's eye position) under an angle of 1 arcmin (see Figure 5).

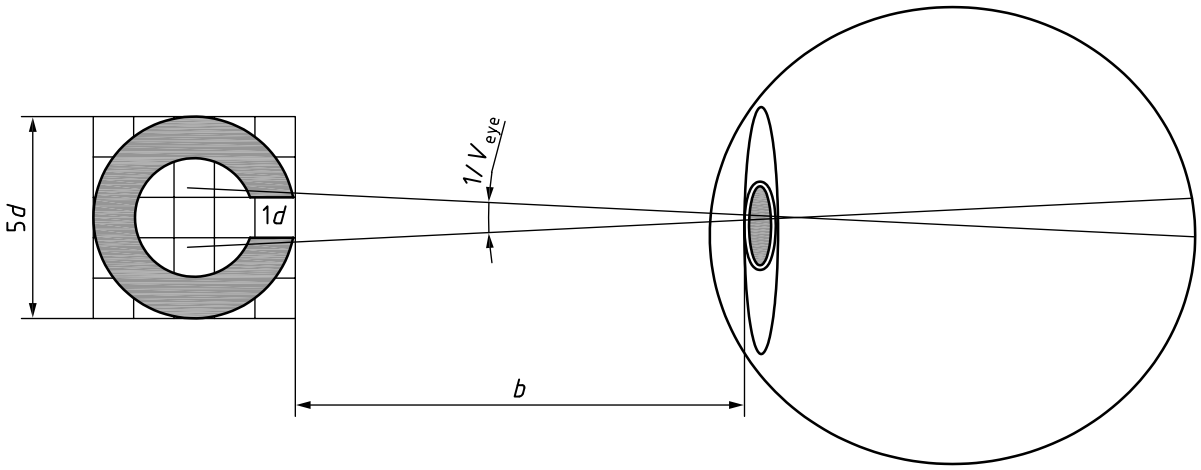


Figure 5 — Example of visual acuity of the human eye tested with Landolt C ring

3.2.30
minimum visual acuity of the human eye
minimum value of V_{eye}

Note 1 to entry: It is denoted as $V_{eye/min}$:

— for UN Regulation No. 46 class I mirrors, this value is defined as $V_{eye/min}$ = 0,7;

— for UN Regulation No. 46 class II mirrors, this value is defined as $V_{eye/min}$ = 0,8;

— for UN Regulation No. 46 class III mirrors, this value is defined as $V_{eye/min}$ = 0,7;

— for UN Regulation No. 46 class IV mirrors, this value is defined as $V_{eye/min}$ = 0,8.

Note 2 to entry: FeV, the German requirements for acquiring drivers licenses for passenger vehicles, Appendix 6 §1.1 defines a minimum visual acuity of 0,7. Japan defines 0,7, Netherlands defines 0,5, and Sweden defines 0,5.

Note 3 to entry: In Sweden, Germany, Japan, and Netherlands, driving licenses for C/CE (heavy truck/heavy truck with trailer), D/DE (heavy bus/heavy bus with trailer) type of vehicles, as well as for taxis; minimum 0,8 in binocular acuity is required. Glasses or contact lenses may be used to achieve this acuity.

© ISO 2019 – All rights reserved

Note 4 to entry: There may be differences depending on the market where the vehicle is to be driven.

3.3 Camera related terms and definitions

3.3.1
camera
device used to capture colour images of a specific field of view; it mainly consists of two relevant items: imager and lens

Note 1 to entry: The following definitions assume an ideal camera and do not deal with artefacts like image blur, wrong focus, lens distortion, etc. The tests defined in 7.8 make sure that these artefacts are reduced to a minimum.

3.3.2
camera optical axis
virtual line that defines the path along which light propagates through the system; for a system composed of simple lenses, the axis passes through the centre of curvature of each surface, and coincides with the axis of rotational symmetry

3.3.3
camera reference orientation
orientation of a camera of a CMS where the optical axis of the camera is pointing along the positive x-axis of the vehicle [the camera is looking backwards with the *camera imager* (3.3.7) lying in the y-z-plane] and the camera's upper side normal is parallel to the positive z-axis of the vehicle

Note 1 to entry: It helps to simplify the definition of further parameters of the camera (see Figure 6). See also *vehicle coordinate system* (3.1.2) for coordinate convention used.

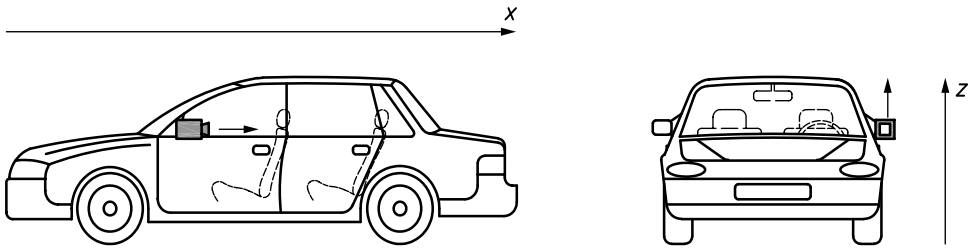


Figure 6 — Camera reference orientation

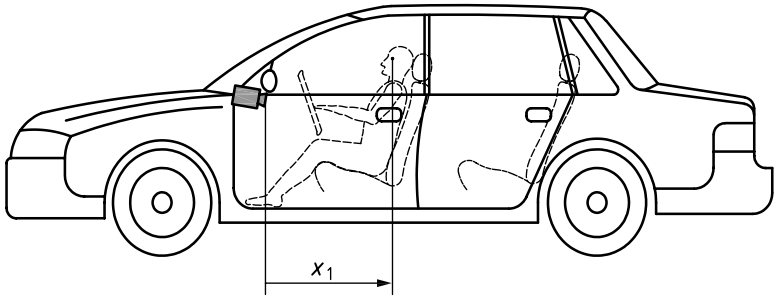
3.3.4
camera distance to driver ocular reference point in x-direction
distance from the centre of the *entrance pupil of the camera* (3.3.13) to the *driver ocular reference point* (3.1.4) in x-direction when mounted to the vehicle; it is specific for each vehicle, even if the camera itself is the same for each vehicle

Note 1 to entry: See Figure 7.

Note 2 to entry: It is denoted as x_{camera} and is measured in metres.

Note 3 to entry: For camera positions forward of the ORP, x_{camera} has to be a positive value while for camera positions rear of the ORP, x_{camera} has to be a negative value.

© ISO 2019 – All rights reserved



Key

X_1 x_{camera}

Figure 7 — Distance to driver ocular reference point in x-direction

3.3.5
camera distances in y-direction

displacement from the outermost point of the same side of the vehicle to the entrance pupil of a camera replacing side mirrors in y-direction is denoted as y_{camera}, and displacement from the longitudinal centre x-z-plane to the entrance pupil of a camera replacing the interior centre mirror in y-direction is denoted as y'_{camera}

Note 1 to entry: Distances are measured in metres (see Figure 8).

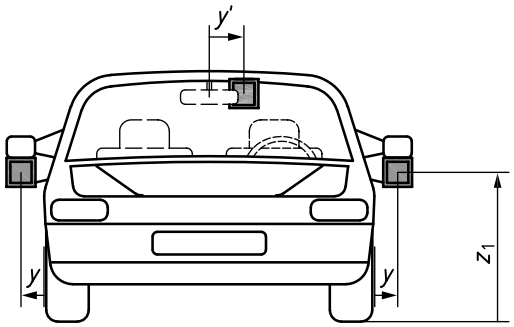
Note 2 to entry: For camera positions located outboard of the outermost point of the vehicle, y_{camera} has to be a positive value while for camera positions located inboard of the outermost point of the vehicle, y_{camera} has to be a negative value.

Note 3 to entry: For camera positions located in positive y-direction, y'_{camera} has to be a positive value while for camera positions located in negative y-direction, y'_{camera} has to be a negative value.

3.3.6
camera height above road surface

distance from the road surface to the centre of the *entrance pupil of the camera* (3.3.13) in z-direction when mounted to the vehicle; it is specific for each vehicle, even if the camera itself is the same for each vehicle

Note 1 to entry: It is denoted as z_{camera} and is measured in metres.



Key

y y_{camera}

y' y'_{camera}

Z_1 z_{camera}

Figure 8 — Height above road surface

© ISO 2019 – All rights reserved

Note 2 to entry: For some vehicles (e.g. heavy trucks), different chassis variants and/or wheel dimensions are common depending on what type of transport the vehicle is intended for. It is important to be aware of this as the actual height above road surface will influence the requirement fulfilment by the CMS. Often, there will be worst case variants to consider.

3.3.7
camera imager
rectangular device that transforms electromagnetic radiation (irradiance) mostly of visible wavelength into electric currents; it is subdivided into a matrix of smaller (usually squared) active areas

3.3.8
camera pixel
smallest active area in a matrix of several active areas forming an imager

Note 1 to entry: It is an abbreviated term for picture element.

EXAMPLE For a Bayer pattern imager, it is either the green, blue, or red filtered pixel.

3.3.9
camera resolution
measure of the ability of a camera system to depict picture detail

Note 1 to entry: The specification hereinafter will assume a camera orientation where the imager axes are parallel to the coordinate axes when CMS camera is fixed to the body of the vehicle. For all other CMS systems composed of a different configuration, those specifications shall meet the same or increased perceptibility to the specification cited herein, under above consideration.

3.3.10
camera horizontal pixel resolution
number of pixels of the imager in y-direction for a *camera in reference orientation* (3.3.3)

Note 1 to entry: It is denoted as $N_{camera/hor}$; this is not necessarily the scanning direction of the imager.

3.3.11
camera vertical pixel resolution
number of pixels of the imager in z-direction for a *camera in reference orientation* (3.3.3)

Note 1 to entry: It is denoted as $N_{camera/ver}$.

3.3.12
camera lens
optical device of one or more optical elements that collects the incident light reflected or emitted from the scene and focuses the target scene image on to the surface of the imager

3.3.13
camera entrance pupil
optical image of the physical aperture stop seen through the front lens of the system; it is also defined as the vertex of the camera's field of view; it is influenced by the lens and is also sometimes called the "projection centre" or "centre of projection"; for simplicity, it is approximated by the centre of the outermost lens surface

Note 1 to entry: It is denoted as EP_{camera} and is a coordinate triplet given in metres.

3.3.14
camera field of view
space defined by all rays of light (lines from the centre of the entrance pupil of a camera to object points) that are projected onto the imager; for a camera fulfilling the recommendation of minimum geometric distortion, this space can be approximated by a pyramid with its apex lying in the centre of the entrance pupil and its base lying in the y-z-plane for a *camera in reference orientation* (3.3.3)

Note 1 to entry: See 6.8.6.

© ISO 2019 – All rights reserved

3.3.15
camera horizontal field of view
angle between the leftmost and the rightmost ray of the field of view projected to the x-y-plane for a *camera in reference orientation* (3.3.3)

Note 1 to entry: It is denoted as $\alpha_{camera/hor}$ and measured in degrees. It is sometimes also called the horizontal opening angle of a camera.

Note 2 to entry: See Figure 9.

3.3.16
camera vertical field of view
angle between the topmost and the bottommost ray of the field of view projected to the x-z-plane for a *camera in reference orientation* (3.3.3)

Note 1 to entry: It is denoted as $\alpha_{camera/ver}$ and measured in degrees. It is sometimes also called the vertical opening angle of a camera.

Note 2 to entry: See Figure 9.

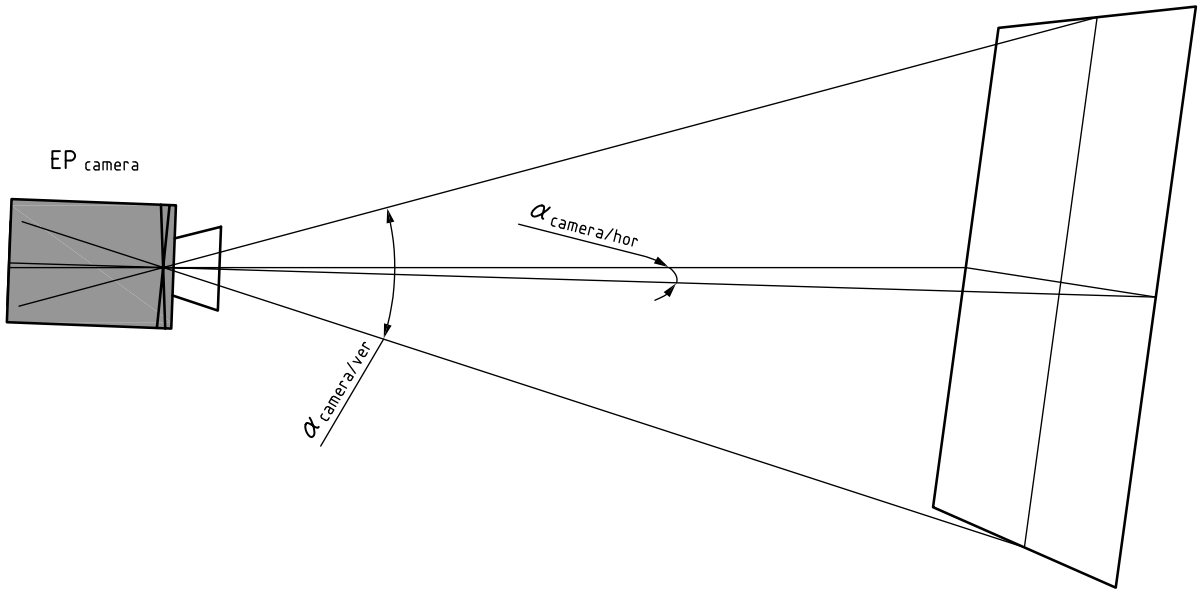


Figure 9 — Horizontal and vertical camera field of view

3.3.17
camera angular resolution
parameter describing the ability of a camera to resolve small details in a captured scene; it does not only take into account the mere resolution of the imager but also relating it to the field of view that the camera is capturing; the smaller the angular resolution of a camera, the smaller the details that can be resolved by the camera, i.e. in contrast to the pixel resolution, smaller values for the angular resolution indicate a more detailed camera image

3.4 Monitor related terms and definitions

3.4.1
monitor
device for displaying images; it either consists of a matrix of active areas that radiate light of different wavelengths or is a (usually diffuse) reflector that is illuminated in different wavelengths and in a matrix of specific points by a projector

Note 1 to entry: The following definitions assume an ideal monitor and do not deal with artefacts like pixel defects etc. The tests defined in Clause 7 ensure that these artefacts are kept to a minimum.

© ISO 2019 – All rights reserved

3.4.2
monitor coordinate system
spherical coordinate system ($a_{monitor}$, $\Theta_{monitor}$, $\Phi_{monitor}$) of the monitor; it is mainly used for evaluation of the viewing angle dependent visual performance of the monitor; the origin of the spherical coordinate system is placed in the centre of the active area of the monitor

[SOURCE: ISO 9241-302:2008, 3.3.19, modified]

Note 1 to entry: See Figure 10.

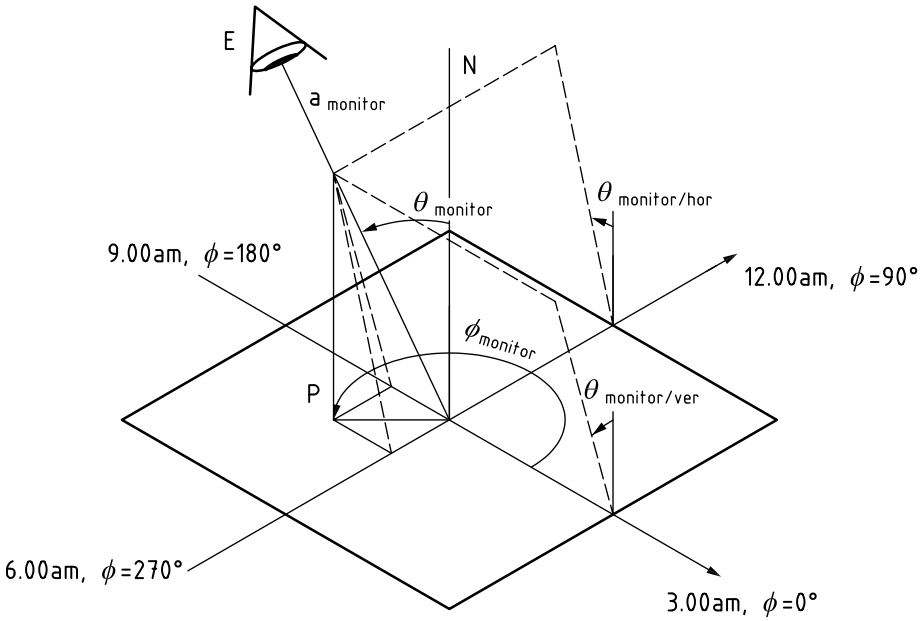


Figure 10 — Monitor spherical coordinate system

3.4.3
monitor viewing direction
direction from which the monitor is viewed; it is a line from the mid-eye point of the viewer to the centre of the monitor coordinate system

Note 1 to entry: The mid-eye point is the actual middle point between the driver's eyes. This point varies with the driver's head movement.

3.4.4
monitor viewing distance
distance of the mid-eye point of the viewer to the centre of the monitor coordinate system

Note 1 to entry: It is denoted as $a_{monitor}$ and is measured in metres.

3.4.5
monitor viewing inclination angle
inclination angle of the monitor viewing direction in monitor coordinates

Note 1 to entry: It is denoted as $\Theta_{monitor}$ and is measured in degrees.

Note 2 to entry: See Figure 10.

Note 3 to entry: From the *monitor horizontal viewing angle* (3.4.7) and the *monitor vertical viewing angle* (3.4.8), this value can be derived as:

$$\Theta_{monitor} = \arctan\sqrt{\tan^2\theta_{monitor/hor} + \tan^2\theta_{monitor/ver}} \quad (1)$$

© ISO 2019 – All rights reserved

3.4.6
monitor viewing azimuthal angle
azimuthal angle of the monitor viewing direction in monitor coordinates; it is measured counterclockwise and starting at 3 o'clock

Note 1 to entry: 3 o'clock is the right edge and 12 o'clock is the upper edge of the monitor as seen from the driver.

Note 2 to entry: It is denoted as $\Phi_{monitor}$ and is measured in degrees.

Note 3 to entry: See Figure 10.

Note 4 to entry: From the *monitor horizontal viewing angle* (3.4.7) and the *monitor vertical viewing angle* (3.4.8), this value can be derived as:

$$\Phi_{monitor} = \arctan\left(\frac{\tan\theta_{monitor/ver}}{\tan\theta_{monitor/hor}}\right) \quad (2)$$

3.4.7
monitor horizontal viewing angle
monitor viewing inclination angle projected onto the plane defined by the monitor surface normal and the 12 o'clock direction

Note 1 to entry: It is denoted as $\theta_{monitor/hor}$ and is measured in degrees:

$$\theta_{monitor/hor} = \arctan\left[\tan\left(\Theta_{monitor}\right)\cdot\cos\left(\Phi_{monitor}\right)\right] \quad (3)$$

Note 2 to entry: See Figure 10 and Figure 12.

3.4.8
monitor vertical viewing angle
monitor viewing inclination angle projected onto the plane defined by the monitor surface normal and the 3 o'clock direction

Note 1 to entry: It is denoted as $\theta_{monitor/ver}$ and is measured in degrees:

$$\theta_{monitor/ver} = \arctan\left[\tan\left(\Theta_{monitor}\right)\cdot\sin\left(\Phi_{monitor}\right)\right] \quad (4)$$

Note 2 to entry: See Figure 10 and Figure 12.

3.4.9
monitor design viewing direction
specific monitor viewing direction allocated to the ORP and the specific vehicle design (i.e. monitor placement and rotation) indicated by the index "D"

3.4.10
monitor design viewing distance
distance of the ORP to the centre of the monitor coordinate system

Note 1 to entry: It is denoted as $a_{monitor/D}$ and is measured in metres.

3.4.11
monitor design viewing inclination angle
monitor viewing inclination angle derived from the monitor design viewing direction

Note 1 to entry: It is denoted as $\Theta_{monitor/D}$ and is measured in degrees.

© ISO 2019 – All rights reserved

3.4.12
monitor design viewing azimuthal angle
monitor viewing azimuthal angle derived from the monitor design viewing direction

Note 1 to entry: It is denoted as $\Phi_{monitor/D}$ and is measured in degrees.

3.4.13
monitor design horizontal viewing angle
monitor horizontal viewing angle derived from the monitor design viewing direction

Note 1 to entry: It is denoted as $\theta_{monitor/hor/D}$ and is measured in degrees.

Note 2 to entry: See Figure 10 and Figure 12.

3.4.14
monitor design vertical viewing angle
monitor vertical viewing angle derived from the monitor design viewing direction

Note 1 to entry: It is denoted as $\theta_{monitor/ver/D}$ and is measured in degrees.

Note 2 to entry: See Figure 10 and Figure 12.

3.4.15
monitor pixel
smallest distinct able area on the monitor displaying a specific colour usually by additive mixing of the three primary colours (red, green, and blue) in different intensities

3.4.16
monitor defined size
portion of the monitor active area displaying at least the required field of view

Note 1 to entry: The monitor active area, as well as the displayed camera image, may extend beyond this area.

Note 2 to entry: The monitor defined size is defined by the system manufacturer.

Note 3 to entry: See *monitor defined horizontal size* (3.4.17) and *monitor defined vertical size* (3.4.18) for details and differentiation between horizontal and vertical size.

3.4.17
monitor defined horizontal size
portion of the monitor active area displaying at least the required horizontal field of view along the axis from 9 o'clock to 3 o'clock according to Figure 11

Note 1 to entry: It is denoted as $W_{monitor/hor}$ and is measured in metres.

3.4.18
monitor defined vertical size
portion of the monitor active area displaying at least the required vertical field of view along the axis from 6 o'clock to 12 o'clock according to Figure 11

Note 1 to entry: It is denoted as $H_{monitor/ver}$ and is measured in metres.

© ISO 2019 – All rights reserved

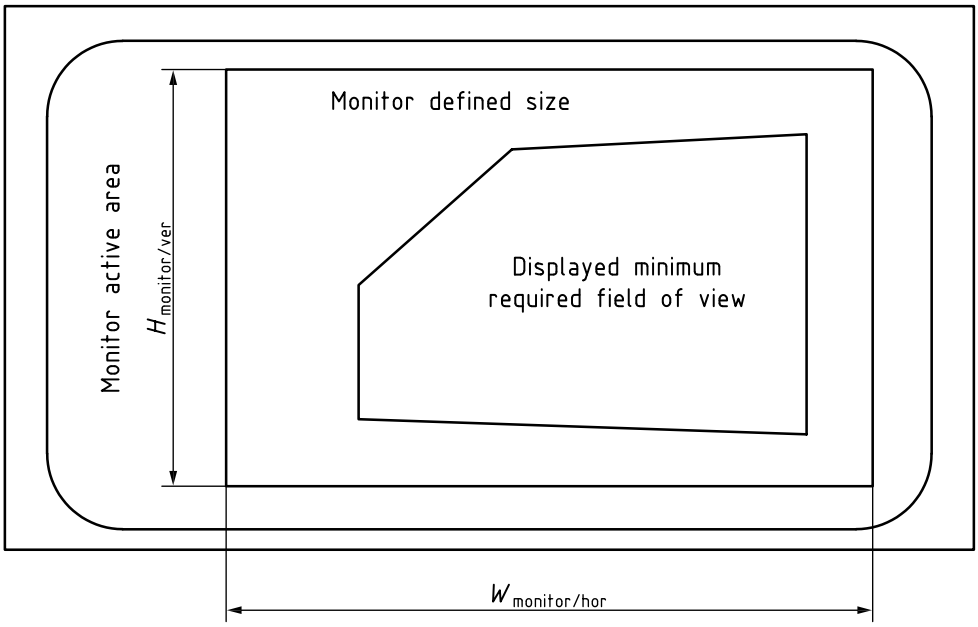


Figure 11 — Example of monitor defined size

3.4.19
monitor angular size
angle under which the driver would perceive the monitor defined size for $\Theta_{monitor} = 0°$ and $a_{monitor} = a_{monitor/D}$

Note 1 to entry: See *monitor horizontal angular size* (3.4.20) and *monitor vertical angular size* (3.4.21) for details and differentiation between horizontal and vertical angular size.

3.4.20
monitor horizontal angular size
angle between the lines from the ORP to the left and right edge of the monitor defined horizontal size for $\Theta_{monitor} = 0°$ and $a_{monitor} = a_{monitor/D}$

$$\alpha'_{monitor/hor} = 2\arctan\left(\frac{W_{monitor/hor}}{2a_{monitor/D}}\right) \tag{5}$$

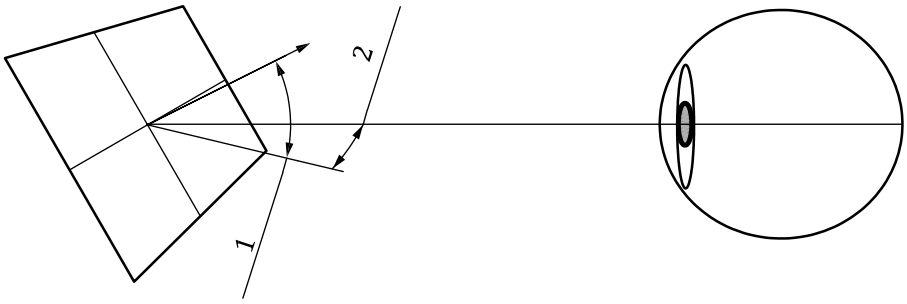
3.4.21
monitor vertical angular size
angle between the lines from the ORP to the top and bottom edge of the monitor defined vertical size for $\Theta_{monitor} = 0$ and $a_{monitor} = a_{monitor/D}$

$$\alpha'_{monitor/ver} = 2\arctan\left(\frac{H_{monitor/ver}}{2a_{monitor/D}}\right) \tag{6}$$

3.4.22
monitor design angular size
actual angular size of the monitor defined size as perceived from the driver in the specific vehicle design (i.e. seen from the monitor design viewing direction $\Theta_{monitor} = \Theta_{monitor/D}$, $\Phi_{monitor} = \Phi_{monitor/D}$, and $a_{monitor} = a_{monitor/D}$)

Note 1 to entry: See *monitor design horizontal angular size* (3.4.23) and *monitor design vertical angular size* (3.4.24) for details and differentiation between horizontal and vertical angular size.

© ISO 2019 – All rights reserved



Key

1 $\theta_{monitor/ver}$

2 $\theta_{monitor/hor}$

Figure 12 — Perspective view of horizontal and vertical viewing angle

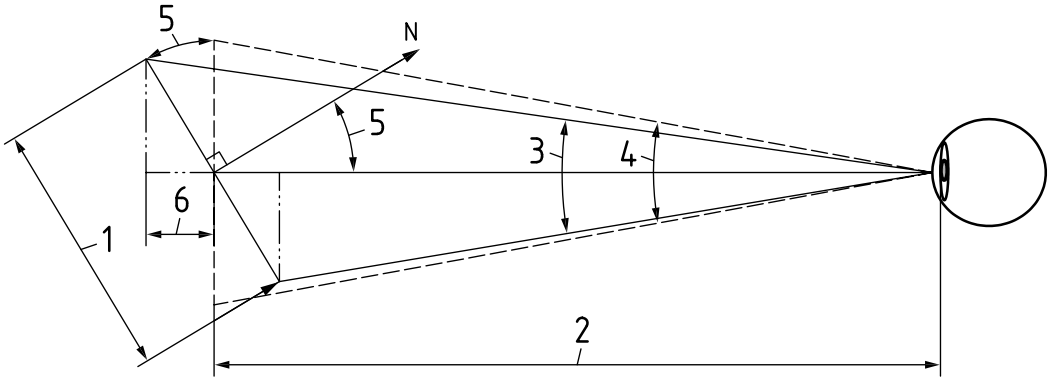
3.4.23
monitor design horizontal angular size
actual angular size of the monitor defined size as perceived from the driver in the specific vehicle design measured in the direction of the horizontal extent of the monitor

$$\alpha'_{monitor/hor/D} = \arctan\left\{\frac{\frac{1}{2}\cdot W_{monitor/hor}\cdot\cos\left(\theta_{monitor/hor/D}\right)}{a_{monitor/D}+\left[\frac{1}{2}\cdot W_{monitor/hor}\cdot\sin\left(\theta_{monitor/hor/D}\right)\right]}\right\} + \arctan\left\{\frac{\frac{1}{2}\cdot W_{monitor/hor}\cdot\cos\left(\theta_{monitor/hor/D}\right)}{a_{monitor/D}-\left[\frac{1}{2}\cdot W_{monitor/hor}\cdot\sin\left(\theta_{monitor/hor/D}\right)\right]}\right\} \quad (7)$$

Note 1 to entry: For $W_{monitor/hor} << a_{monitor/D}$, Formula (7) can be simplified to $\alpha'_{monitor/hor/D} = \cos(\theta_{monitor/hor/D}) \cdot \alpha'_{monitor/hor}$.

Note 2 to entry: See Figure 13.

© ISO 2019 – All rights reserved



Key

1 $W_{monitor/hor}$, horizontal size of the monitor, tilted at centre

2 $a_{monitor/D}$

3 $\alpha'_{\text{monitor/hor/D}}$

4 $\alpha'_{monitor/hor}$, horizontal angular size of the monitor as seen from $\theta_{monitor/hor} = 0$

5 $\theta_{\text{monitor/hor/D}}$

6 $\frac{1}{2} W_{monitor/hor} * \sin\left(\theta_{monitor/hor/D}\right)$

Figure 13 — Monitor design horizontal angular size

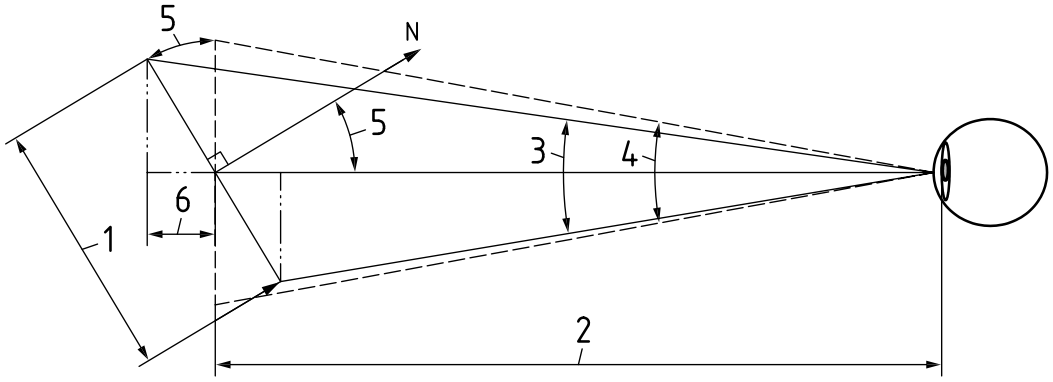
3.4.24
monitor design vertical angular size
actual angular size of the monitor defined size as perceived from the driver in the specific vehicle design measured in direction of the vertical extent of the monitor

$$\alpha'_{monitor/ver/D} = \arctan\left\{\frac{\frac{1}{2}\cdot H_{monitor/ver}\cdot\cos\left(\theta_{monitor/ver/D}\right)}{a_{monitor/D}+\left[\frac{1}{2}\cdot H_{monitor/ver}\cdot\sin\left(\theta_{monitor/ver/D}\right)\right]}\right\} + \arctan\left\{\frac{\frac{1}{2}\cdot H_{monitor/ver}\cdot\cos\left(\theta_{monitor/ver/D}\right)}{a_{monitor/D}-\left[\frac{1}{2}\cdot H_{monitor/ver}\cdot\sin\left(\theta_{monitor/ver/D}\right)\right]}\right\} \quad (8)$$

Note 1 to entry: For $H_{monitor/ver} << a_{monitor/D}$, Formula (8) can be simplified to $\alpha'_{monitor/ver/D} = \cos(\theta_{monitor/ver/D}) \cdot \alpha'_{monitor/ver}$.

Note 2 to entry: See Figure 14.

© ISO 2019 – All rights reserved



Key

1 $H_{monitor/ver}$, vertical size of the monitor, tilted at centre

2 $a_{monitor/D}$

3 $\alpha'_{\text{monitor/ver/D}}$

4 $\alpha'_{monitor/ver}$, vertical angular size of the monitor as seen from $\theta_{monitor/ver} = 0$

5 $\theta_{\text{monitor/ver/D}}$

6 $\frac{1}{2} H_{monitor/ver} * \sin(\theta_{monitor/ver/D})$

Figure 14 — Monitor design vertical angular size

3.4.25
monitor displayed field of view
portion of the camera's field of view that is actually displayed on the monitor defined size

3.4.26
monitor horizontal percentage of displayed camera field of view
percentage of the camera's horizontal field of view that is actually visible on the monitor defined horizontal size

Note 1 to entry: It is denoted as $p_{camera/hor}$ and is given in percent.

3.4.27
monitor vertical percentage of displayed camera field of view
percentage of the camera's vertical field of view that is actually visible on the monitor defined vertical size

Note 1 to entry: It is denoted as $p_{camera/ver}$ and is given in percent.

3.4.28
field of view displayed in the monitor defined horizontal size
portion of the camera's field of view that is actually displayed on the monitor defined horizontal size

$$\alpha_{monitor/hor} = \alpha_{camera/hor} * p_{camera/hor} \tag{9}$$

3.4.29
field of view displayed in the monitor defined vertical size
portion of the camera's field of view that is actually displayed on the monitor defined vertical size

$$\alpha_{monitor/ver} = \alpha_{camera/ver} * p_{camera/ver} \tag{10}$$

© ISO 2019 – All rights reserved

3.4.30
monitor displayed angular resolution
parameter that describes the ability of the monitor to resolve small details in the displayed scene

Note 1 to entry: It considers the mere resolution of the monitor and its relation to the field of view, the monitor is displaying.

Note 2 to entry: The smaller the angular resolution of a monitor, the smaller the details can be that are still resolved by the monitor.

3.4.31
monitor standard isotropy range
specific vertical range of 6 ° up and 6 ° down from the *monitor design vertical viewing angle* (3.4.14), and specific horizontal range of 7 ° right and 7 ° left from the *monitor design horizontal viewing angle* (3.4.13)

Note 1 to entry: The value is derived from the eye ellipse definition given in ISO 4513:2010, Table 2, with $a_{monitor}$ equals 60 cm.

3.4.32
monitor extended isotropy range
additional 5 ° from the standard isotropy range in the vertical and horizontal directions

Note 1 to entry: This additional range covers head movements.

3.4.33
image formation time
summation of the rise time and the fall time as defined in ISO 9241-302:2008, 3.4.14

3.5 Camera Monitor System based terms and definitions

3.5.1
Camera Monitor System
CMS
entity used in vehicles that presents the required outside information of a specific field of view to the driver of the vehicle, replacing conventional mirror system by means of electronic image capture and display devices

Note 1 to entry: It consists of a *camera* (3.3.1) that is usually installed at the bodywork of a vehicle and a *monitor* (3.4.1) that is usually placed inside the vehicle.

3.5.2
CMS system overview
scheme that comprises the black box of a functional system and its interfaces

Note 1 to entry: See Figure 15.

© ISO 2019 – All rights reserved

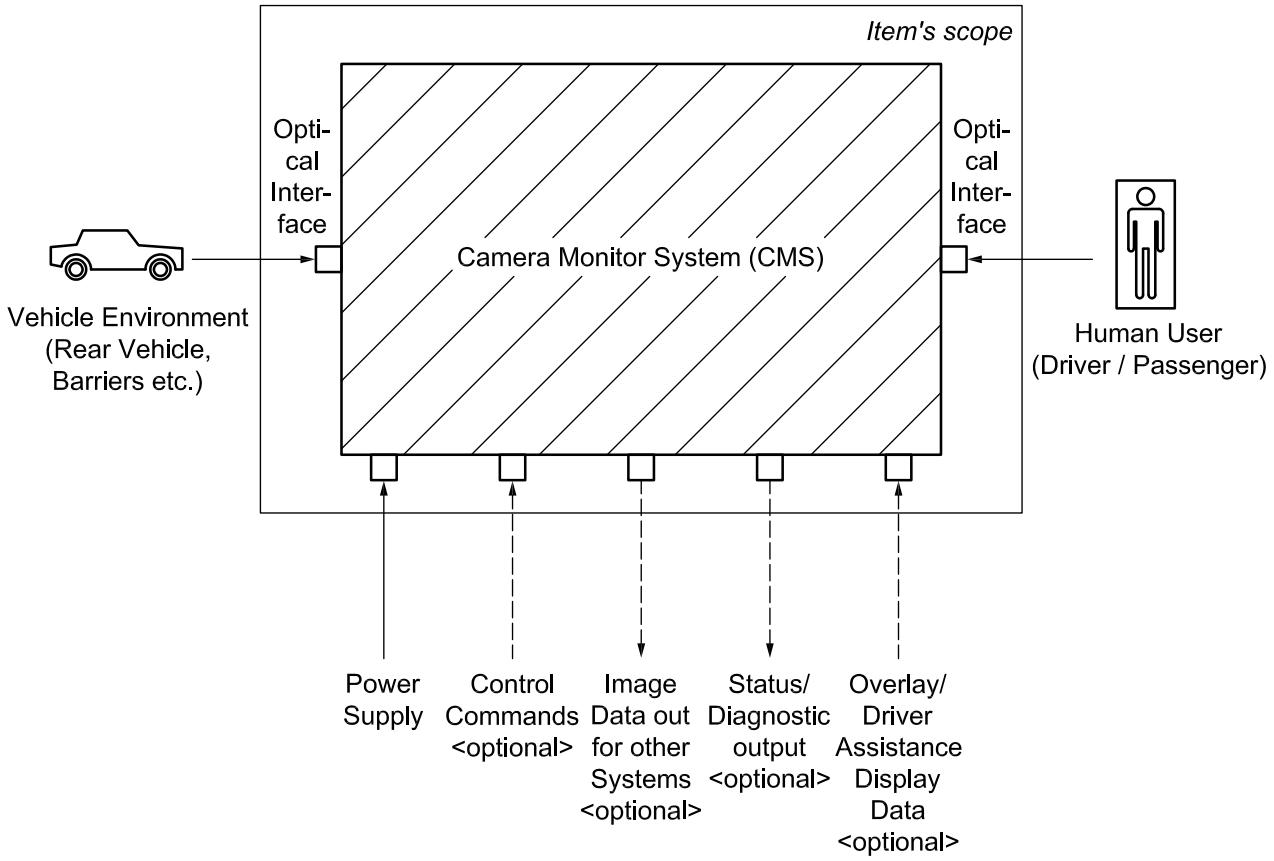


Figure 15 — System block diagram

Note 2 to entry: The external interfaces of the CMS are the following:

— captured optical signal from the vehicle's surrounding environment (technical realization: e.g. camera);

— optical image shown to the driver or a passenger (technical realization: e.g. display);

— power supply;

— control commands, e.g. on/off command (unless technically linked to the toggling of the power supply), and optionally choice of the image zoom factor, viewing area, contrast, brightness, etc.;

— optionally, image data output for other ADAS, which are not the scope of this document;

— optionally, status/diagnostic output signal (e.g. to activate warning lamp in the instrument cluster);

— optionally, overlay information or driver assistance display data from other ADAS, which are not in the scope of this document.

Note 3 to entry: The following entities are usually interacting with the CMS:

— vehicle on-board network (e.g. CAN, FlexRay, LIN, etc.);

— optionally, control elements (e.g. switches, buttons, joystick, menu entries, etc.);

— optionally, ADAS, which provide additional information on the display graphically or use images captured by the camera for their purposes.

3.5.3
CMS functional structure
system that is functionally divided in its essential parts

Note 1 to entry: See Figure 16.

© ISO 2019 – All rights reserved

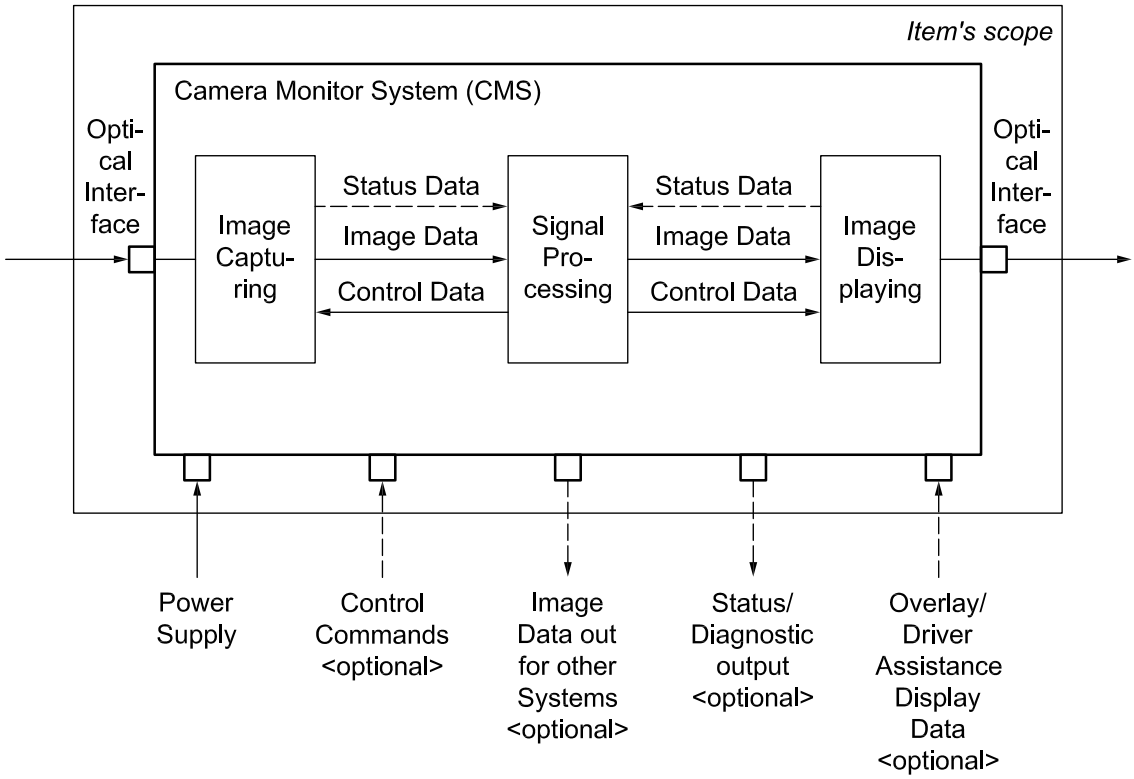


Figure 16 — CMS as white box

Note 2 to entry: A CMS is functionally divided in three essential parts:

— image capturing;

— image processing;

— image displaying, independent of different display technologies (e.g. flat screen, projection).

Note 3 to entry: The main task of the image capturing is to capture the visual surrounding field of the vehicle. It is realized by a camera, without regard to its implementation technologies.

Note 4 to entry: The image processing processes the image captured to realize display characteristics on the display unit, e.g. brightness or contrast adaptation, filtering, etc. It can be realized in hardware or software, either as a separate device, or integrated directly into the camera or in the display unit. Besides, the image processing part computes necessary controls of the camera (e.g. zoom) or display unit and also processes user inputs, if available, and optionally interface data from/to external ADAS.

Note 5 to entry: The image displaying represents the actual computed image in the vehicle on a screen or display at an appropriate viewing position for the driver. It can be realized for example by flat screen, projection, etc.

3.5.4
CMS field of view
field of view that a driver using the CMS is really able to observe; it is equal with the displayed field of view; for CMS with one camera and one monitor, this value is always less or equal to the camera field of view

3.5.5
CMS horizontal field of view
field of view that a driver using the CMS is really able to observe along the monitor defined horizontal size

Note 1 to entry: It is equal with the field of view displayed in the monitor horizontal size.

© ISO 2019 – All rights reserved

$$\alpha_{system/hor} = \alpha_{monitor/hor} \tag{11}$$

3.5.6
CMS vertical field of view
field of view that a driver using the CMS is really able to observe along the monitor defined vertical size

Note 1 to entry: It is equal with the field of view displayed in the monitor vertical size.

$$\alpha_{system/ver} = \alpha_{monitor/ver} \tag{12}$$

3.5.7
CMS magnification factor
defines the relationship between the angular size of an object as seen by the camera and the angular size as it is perceived by the driver on the monitor of the CMS

Note 1 to entry: It is denoted as M_{system}.

3.5.8
CMS average magnification factor
average value for the magnification of the CMS based on the relationship between $\alpha_{monitor}$, i.e. the displayed field of view, and $\alpha'_{monitor/D}$, i.e. the monitor design angular size

Note 1 to entry: It is denoted as $M_{system/avg}$.

3.5.9
CMS horizontal average magnification factor
horizontal average magnification of the scene observed through the CMS is given by:

$$M_{system/hor/avg} = \frac{\alpha'_{monitor/hor/D}}{\alpha_{monitor/hor}} \approx \cos\left(\theta_{monitor/hor/D}\right) * \left\{ \frac{2\arctan\left(\frac{W_{monitor/hor}}{2a_{monitor/D}}\right)}{\alpha_{camera/hor} * p_{camera/hor}} \right\} \tag{13}$$

where

$\theta_{monitor/hor/D}$ is the *monitor's design horizontal viewing angle* (3.4.13);

$a_{monitor/D}$ is the distance of the ORP to the centre of the monitor coordinate system (see 3.4.10);

$W_{monitor/hor}$ is the *monitor defined horizontal size* (3.4.17);

$\alpha_{camera/hor}$ is the *camera's horizontal field of view* (3.3.15);

$p_{camera/hor}$ is the percentage of the camera's field of view as displayed on the monitor (see 3.4.26).

3.5.10
CMS vertical average magnification factor
vertical average magnification of the scene observed through the CMS is given by:

$$M_{system/ver/avg} = \frac{\alpha'_{monitor/ver/D}}{\alpha_{monitor/ver}} \approx \cos\left(\theta_{monitor/ver/D}\right) * \left\{ \frac{2\arctan\left(\frac{H_{monitor/ver}}{2a_{monitor/D}}\right)}{\alpha_{camera/ver} * p_{camera/ver}} \right\} \tag{14}$$

© ISO 2019 – All rights reserved

where

$\theta_{monitor/ver/D}$ is the *monitor's design vertical viewing angle* (3.4.14);

$a_{monitor/D}$ is the design distance of the monitor to the ORP (see 3.4.10);

$H_{monitor/ver}$ is the *monitor defined vertical size* (3.4.18);

$\alpha_{camera/ver}$ is the *camera's vertical field of view* (3.3.16);

$p_{camera/ver}$ percentage of the camera's field of view as displayed on the monitor (see 3.4.27).

3.5.11
CMS minimum magnification factor
minimum value for the magnification the CMS shows in the required field of view as defined in 6.5

Note 1 to entry: It is denoted as $M_{system/hor/min}$ for horizontal direction and $M_{system/ver/min}$ for vertical direction.

3.5.12
CMS angular resolution
combination of the *camera angular resolution* (3.3.17) and the *monitor displayed angular resolution* (3.4.30); it describes the ability of the CMS as a whole to resolve small details in the displayed scene and is defined as the maximum of both values

Note 1 to entry: If the camera is not capturing a certain detail (i.e. it does not have a sufficient angular resolution), the monitor will not be able to display it, so the camera limits the angular resolution of the CMS. On the other hand, in case the monitor is displaying the camera image (i.e. the captured field of view) with less pixel resolution, it is the monitor that limits the angular resolution of the CMS, as details that are present in the camera image cannot be displayed and, thus, are not observable by the user. It has to be the maximum of both values, as smaller values for the angular resolution indicate a higher quality for the displayed scene.

3.5.13
CMS overlay
any driving-related visual information added to the original image (such as icons, labels, coloured areas, etc.) that modifies it in a way that part of the original information is hidden; overlays can be partially transparent or totally opaque and can be displayed temporary or permanently

3.6
signal to noise ratio
ratio of the usable wanted optical signal to unwanted noise

3.7
point light source
light source of very small angular extend of about 2 arcmin and has a luminance of more than 300 cd/m^2

EXAMPLE Low beam headlights with a dimension of about 20 cm width in 350 m distance.

3.8
glare
condition of vision in which there is discomfort or a reduction in the ability to see details or objects, caused by an unsuitable distribution or range of luminance or by extreme contrasts

3.9
glare source
very bright light source like the sun or the headlights of a vehicle

Note 1 to entry: Table 1 below shows some typical luminance values that are relevant for the case of a camera monitor system observing a road scene.

© ISO 2019 – All rights reserved

Table 1 — Typical luminance values relevant for camera monitor systems in road vehicles

Object	Luminance
Clear sky	8 000 cd/m^2
Night sky at full moon	0,1 cd/m^2
60 W light bulb	120 × 10^3 cd/m^2
TFT white	500 cd/m^2
TFT black	0,8 cd/m^2
White LED	50 × 10^6 cd/m^2
Sun (clear day at noon)	1,6 × 10^9 cd/m^2

3.10
glare scenario
situation where a glare source is shining directly into the imaging system

3.11
parking situation
driving situation that includes all low speed manoeuvring with a vehicle or vehicle combination where it is important to precisely manoeuvre to the right spot ending at a certain vehicle orientation without colliding or interfering with surrounding objects

3.12
modulation transfer function
MTF
quantitative means to measure the spatial frequency capability as a modulus of the signal amplitude at which the individual black and white lines (or also described as line and space) of a test pattern are captured and transferred as output signal and reproduced on a display

Note 1 to entry: An MTF plot is obtained as signal amplitude response to the spatial frequency of the elements J1-J2, K1-K2, JS1-JS2, and KS1-KS2 of the chart shown in ISO 12233:2017, Figure I.2.

Note 2 to entry: An MTF plot can also be obtained by the discrete Fourier transform of the line-spread function, also known as the spatial frequency response (SFR), if the camera signal is not submitted to nonlinear gamma correction and/or image edge enhancement and/or image smoothing process. As this might not apply to most CMS, this method should only be used as a practical method for depth of field measurement.

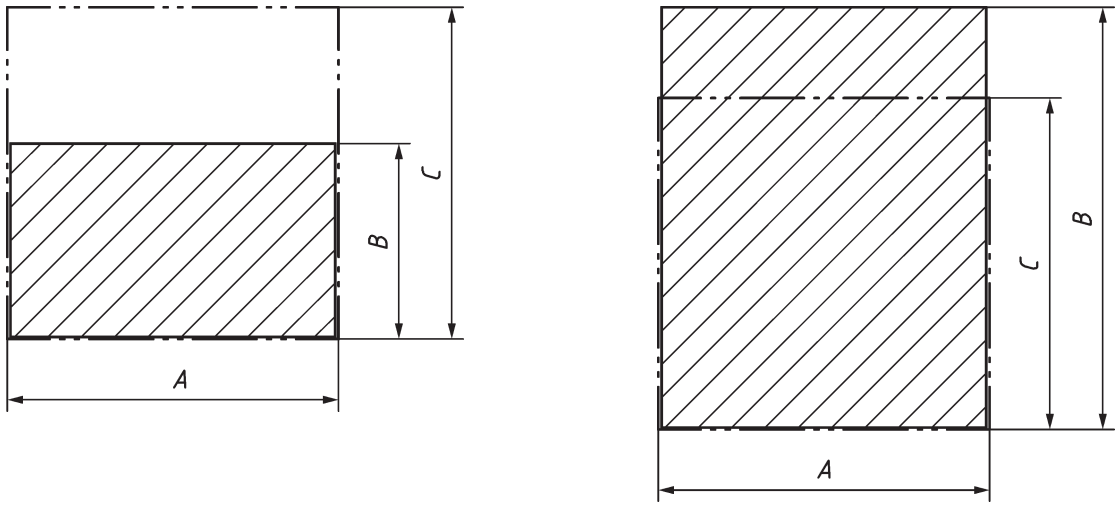
3.13
MTF10
spatial frequency of the *modulation transfer function* (3.12), where an average modulation value is equal to 10 % of the modulation of its black and white reference level, given in [LW/PH] or line widths per picture height

Note 1 to entry: The modulation is the difference between the black and white signal level divided by the sum of these levels. The result shows the limit visual resolution, to perceive fine details of the observed scene through the CMS. For the purpose of fast recognition of the scene, a signal drop limit of 10 % is used, instead of commonly used 5 % which is described as an example of limiting resolution in ISO 12233. The higher the frequency, the higher is the capability of the CMS system to reproduce fine details of the scene.

3.14
MTF10$_{(1:1)/hor}$
is the horizontal spatial frequency of the CMS as measured and converted to an assumed monitor vertical size $H'_{monitor/ver} = W_{monitor/hor}$ resulting in a horizontal versus vertical output aspect ratio of 1:1 using the test procedure given in 7.5.3

Note 1 to entry: See Figure 17.

© ISO 2019 – All rights reserved



a) Landscape monitor **b) Portrait monitor**

Key

A $W_{monitor/hor}$

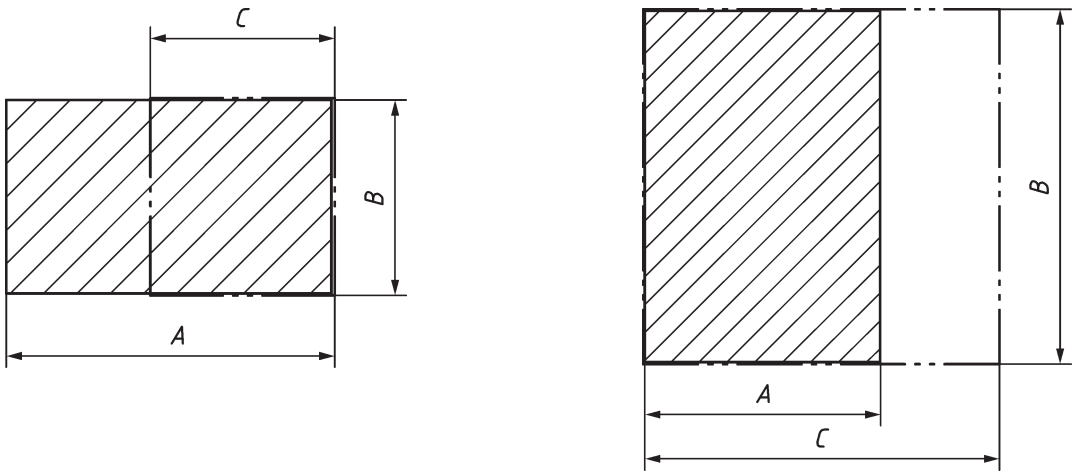
B $H_{monitor/ver}$

C $H'_{monitor/ver}$

Figure 17 — Illustration of the assumed monitor dimensions of $MTF10_{(1:1)/hor}$

3.15
$MTF10_{(1:1)/ver}$
vertical spatial frequency of the CMS as measured and converted to an assumed monitor horizontal size $W'_{monitor/hor} = H_{monitor/ver}$ resulting in a horizontal versus vertical output aspect ratio of 1:1 using the test procedure given in 7.5.3

Note 1 to entry: See Figure 18.



a) Landscape monitor **b) Portrait monitor**

© ISO 2019 – All rights reserved

Key

A $W_{monitor/hor}$

B $H_{monitor/ver}$

C $W'_{monitor/hor}$

Figure 18 — Illustration of the assumed monitor dimensions of $MTF10_{(1:1)/ver}$

3.16
$MTF10_{MIN(1:1)/hor}$
definition of horizontal spatial frequency requirement of resolution (MTF)

Note 1 to entry: It is denoted as $MTF10_{MIN(1:1)/hor}$ and it is measured in line widths per picture height [LW/PH] of an assumed monitor defined size $H'_{monitor/ver} = W_{monitor/hor}$, resulting in a horizontal versus vertical output aspect ratio of 1:1; the requirement is given as observable number of lines along this assumed monitor defined size $H'_{monitor/ver} = W_{monitor/hor}$ and it is calculated as:

$$MTF10_{MIN(1:1)/hor} = \left(\frac{W_{monitor/hor}}{W_{monitor/hor/min}} \right) * M_{mirror/avg} * \alpha_{mirror/hor/min} * V_{eye/min} * 60 \frac{arcmin}{°} \quad (15)$$

Note 2 to entry: The spatial frequency requirement is derived from the number of observable lines in the required field of view of a traditional mirror which is given by: $M_{mirror/avg} * \alpha_{mirror/hor/min} * V_{eye/min} * 60 \frac{arcmin}{°}$. The factor $\left(\frac{W_{monitor/hor}}{W_{monitor/hor/min}} \right)$ in Formula (15) reflects the size correction, as the ratio of the monitor horizontal defined size ($W_{monitor/hor}$) versus the monitor horizontal size displaying the required field of view ($W_{monitor/hor/min}$), compensating for the different size in the monitor defined size measurement.

In a distortion free CMS with a constant magnification throughout the entire monitor defined size, the following approximation applies $\left(\frac{W_{monitor/hor}}{W_{monitor/hor/min}} \right) \approx \left(\frac{\alpha_{monitor/hor}}{\alpha_{mirror/hor/min}} \right)$. For such a system, the calculation formula of the measurable value $MTF10_{MIN(1:1)/hor}$ can be simplified as:

$$MTF10_{MIN(1:1)/hor} = M_{mirror/avg} * \alpha_{monitor/hor} * V_{eye/min} * 60 \frac{arcmin}{°}$$

Note 3 to entry: For the adaptation of resolution measurement according to ISO 12233, the measurable value given for a squared aspect ratio 1:1 with length equal to monitor defined size, has to be corrected to take into account the actual measuring monitor size, according to different aspect ratio or to wider measuring field of view. For details of measurement using the monitor defined size, see D.4, or see D.5 for measurement using a partially cropped square image.

Note 4 to entry: Concerning the resolution MTF requirements, $M_{mirror/avg}$ has to be 0,33 for the FMVSS 111 interior mirror and 0,31 for the driver side exterior mirror.

3.17
$MTF10_{MIN(1:1)/ver}$
definition of vertical spatial frequency requirement of resolution (MTF)

Note 1 to entry: It is denoted as $MTF10_{MIN(1:1)/ver}$ and it is measured in line widths per picture height [LW/PH] of an assumed monitor defined size $W'_{monitor/hor} = H_{monitor/ver}$, resulting in a horizontal versus vertical output aspect ratio of 1:1; the requirement is given as observable number of lines along this assumed monitor defined size $W'_{monitor/hor} = H_{monitor/ver}$ and it is calculated as:

© ISO 2019 – All rights reserved

$$\mathrm{MTF10}_{\mathrm{MIN(1:1)}/ver} = \left(\frac{H_{monitor/ver}}{H_{monitor/ver/\min}} \right) * M_{mirror/avg} * \alpha_{mirror/ver/\min} * V_{eye/\min} * 60 \frac{\mathrm{arcmin}}{^\circ} \quad (16)$$

Note 2 to entry: The spatial frequency requirement is derived from the number of observable lines in the required field of view of a traditional mirror which is given by $M_{mirror/avg} * \alpha_{mirror/ver/\min} * V_{eye/\min} * 60 \frac{\mathrm{arcmin}}{^\circ}$. The factor $\left(\frac{H_{monitor/ver}}{H_{monitor/ver/\min}} \right)$ in Formula (16) reflects the size correction, as the ratio of the monitor vertical defined size ($H_{monitor/ver}$) versus the monitor vertical size displaying the required field of view ($H_{monitor/hor/\min}$), compensating for the different size in the monitor defined size measurement. In a distortion free CMS with a constant magnification throughout the entire monitor defined size, the following approximation applies $\left(\frac{H_{monitor/ver}}{H_{monitor/ver/\min}} \right) \approx \left(\frac{\alpha_{monitor/ver}}{\alpha_{mirror/ver/\min}} \right)$. For such a system, the calculation formula of the measurable value $\mathrm{MTF10}_{\mathrm{MIN(1:1)/ver}}$ can be simplified as $\mathrm{MTF10}_{\mathrm{MIN(1:1)}/ver} = M_{mirror/avg} * \alpha_{monitor/ver} * V_{eye/\min} * 60 \frac{\mathrm{arcmin}}{^\circ}$.

3.18
$\mathbf{MTF50_{MIN(1:1)}}$
spatial frequency of the *modulation transfer function* (3.12), where an average modulation value equal to 50 % of the modulation of its black and white reference level, where the monitor displayed field of view is shown in the monitor defined size, with horizontal versus vertical output aspect ratio of 1:1

Note 1 to entry: Adaptation of measurable value to specific CMS with different aspect ratio or to different measured field of view has to be done accordingly as it is done for $\mathrm{MTF10}_{\mathrm{MIN(1:1)}}$. For more details of unit conversion and measurement, see information given in D.3, D.4 or D.5. Lower frequency of this value results in lower contrast of the scene observed through the CMS and the value is used to characterize the sharpness performance of the CMS.

3.19
luminance white level
luminance of the monitor when driven with an artificial 70 % grey-scale image measured from a specific viewing direction (Θ, Φ)

Note 1 to entry: It is denoted as $L_{monitor/white}(\Theta, \Phi)$ and measured in cd/m^2.

Note 2 to entry: This luminance is representing the white level output of the camera.

3.20
luminance of region white at contrast chart
luminance of a high reflective part of a contrast chart reproducing a contrast ratio CR of at least 20:1; the luminance value is measured with an area luminance photometer in cd/m^2 from the CMS cameras point of view

Note 1 to entry: It is denoted as $L_{chart/white}$.

3.21
luminance of region black at contrast chart
luminance of a low reflective part of a contrast chart reproducing a contrast ratio CR of at least 20:1; the luminance value is measured with an area luminance photometer in cd/m^2 from the CMS cameras point of view

Note 1 to entry: It is denoted as $L_{chart/black}$.

© ISO 2019 – All rights reserved

3.22
luminance of region white at contrast chart reproduced from the monitor
luminance of the high reflective part of a contrast chart (min CR = 20:1) displayed on the CMS monitor; the luminance value is measured at darkroom conditions with an area luminance photometer in cd/m^2 from the design viewing direction

Note 1 to entry: It is denoted as $L_{monitor/chart/white}$.

3.23
luminance of region black at contrast chart reproduced from the monitor
luminance of the low reflective part of a contrast chart (min CR = 20:1) displayed on the CMS monitor; the luminance value is measured with an area luminance photometer in cd/m^2 from the design viewing direction

Note 1 to entry: It is denoted as $L_{monitor/chart/black}$.

3.24
luminance of region white at contrast chart reproduced from the monitor under ambient light
luminance of the high reflective part of a contrast chart (min CR = 20:1) displayed on the CMS monitor; the luminance value is measured at test conditions with ambient light with an area luminance photometer in cd/m^2 from the design viewing direction

Note 1 to entry: It is denoted as $L_{monitor/chart/white/ambient}$.

3.25
luminance of region black at contrast chart reproduced from the monitor under ambient light
luminance of the low reflective part of a contrast chart (min CR = 20:1) displayed on the CMS monitor; the luminance value is measured at test conditions with ambient light with an area luminance photometer in cd/m^2 from the design viewing direction

Note 1 to entry: It is denoted as $L_{monitor/chart/black/ambient}$.

3.26
reflected luminance from ambient light at monitor displaying a bright scene
luminance of the reflected ambient light measured at an area of the monitor displaying a bright part of a contrast chart (min CR = 20:1)

Note 1 to entry: The luminance value is denoted as $L_{r/white}$ and is calculated from measured values with an area luminance photometer in cd/m^2 from the design viewing direction using the following formula:

$$L_{r/white} = L_{monitor/chart/white}\left(ambient\ light\ on\right) - L_{monitor/chart/white}\left(ambient\ light\ off\right) \quad (17)$$

3.27
reflected luminance from ambient light at monitor displaying a dark scene
luminance of the reflected ambient light measured at an area of the monitor displaying a dark part of a contrast chart (min CR = 20:1)

Note 1 to entry: The luminance value is denoted as $L_{r/black}$ and is calculated from measured values with an area luminance photometer in cd/m^2 from the design viewing direction using the following formula:

$$L_{r/black} = L_{monitor/chart/black}\left(ambient\ light\ on\right) - L_{monitor/chart/black}\left(ambient\ light\ off\right) \quad (18)$$

3.28
background luminance
luminance of the monitor displaying the image of a completely dark scene (e. g. the camera covered with opaque tissue), measured in a dark environment

© ISO 2019 – All rights reserved